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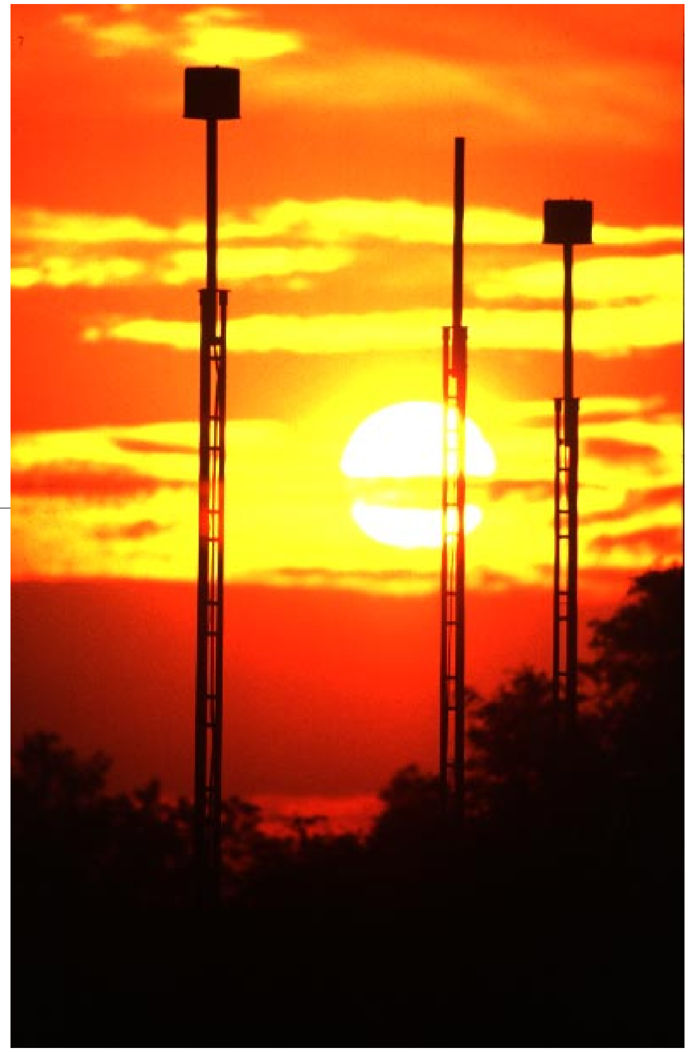
Quality Assurance



CASTNet Base Program

CASTNet DQO have been formulated to provide data of known and documented quality for the continuous field data and the integrated samples, including exposed filters and precipitation. The DQO have been formulated in terms of precision and accuracy. The precision and accuracy objectives for the CASTNet field and laboratory measurements are listed in Tables 6-1 and 6-2.

Precision is a measure of the mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. The primary assessment of overall precision was made using collocated (i.e., duplicate) sets of equipment at selected sites. Direct field measurements and laboratory measurements of field samples were compared in the same way. In addition, all laboratory measurements required two assessments of analytical precision: one to assess sample-to-sample precision within a single analytical data batch, and one to assess batch-to-batch precision. Batch-to-batch precision was estimated only for filter pack analyses and was discontinued after the third quarter of 1998. Precipitation samples were analyzed for numerous parameters and were therefore not suitable for batch-to-batch replication.

The overall precision of meteorological variables and O_3 was assessed quarterly by calculating the difference between simultaneous measurements (i.e., hourly averages) taken by separate instruments at collocated sites. Collocated sites have been selected to be representative of the observed range of pollutant concentrations and environmental conditions that exist within the network. Ashland, ME (ASH135) and Mackville, KY (MCK131) currently operate collocated dry deposition systems. These two sites are the ninth and tenth sites that have operated collocated systems over the history of the network. Concentrations measured at ASH135 are relatively low compared to other eastern sites but are reasonably representative of the entire network. MCK131 measures moderately high concentrations. ALH157 operated a collocated precipitation sampling system during 1998. This is the second site with a collocated precipitation system. SIK570 operated a collocated aerosol sampling system. Sikes is the second visibility site with a collocated system.

The overall precision of atmospheric concentration and wet deposition data was assessed quarterly by calculating the absolute relative percent difference (ARPD) of values for simultaneous samples at collocated sites and averaging these values. Two collocated sites have been found to provide sufficient information to assess whether precision estimates continue to meet CASTNet objectives.

Analytical precision within sample batches was assessed by replicating 5% of the samples within an analysis (in-run replicates). Replicated samples were selected randomly.

Analytical precision from batch to batch for dry deposition anions and NH_4^+ was estimated by analyzing selected samples in two separate batches. Five percent of each batch was selected at random and reanalyzed in a subsequent batch (blind replicates). Although no precision objectives were established for this analysis, comparisons allowed an estimate of batch-to-batch analytical precision. Batch-to-batch replication was discontinued because of the difficulty in interpreting results with respect to in-run replication. In batch-to-batch replication, samples were reanalyzed anywhere from 2 weeks to 2 to 3 months after initial analysis.

The accuracy of field measurements was determined by challenging instruments with standards that were traceable to the NIST. Continuing accuracy was verified during quarterly calibrations during the first half of 1998 and semi-annual calibrations thereafter by ESE personnel and during annual audits by an independent QA auditor. Data accuracy objectives for field measurements are listed in Table 6-1.

In practice, separate DQO are used for field calibrations and for data validation. Table 6-3 provides calibration acceptance (accuracy) criteria for field measurements. For example, an O_3 instrument is adjusted if any calibration result (any point) is outside the ±5 percent DQO. On the other hand, O_3 data are considered valid if results are within ±10 percent (Table 6-1).

The accuracy of laboratory measurements was determined by analyzing an independently prepared reference sample in each batch and calculating the percent recovery relative to the target (theoretical) value. The percent recovery was required to meet or exceed the acceptance criteria listed in Table 6-2. When possible, the reference was traceable to NIST, obtained directly from NIST (when available), or ordered from other laboratories. Unknown reference samples containing SO_4^{2-} and NO_3^- on filter media were also provided by the EPA Project QA Officer. Unknown reference samples provided by EPA were extracted using CASTNet procedures and analyzed at the beginning and end of each IC analytical run.

Network Precision

Field Data

Precision statistics generated via collocated sampling efforts for 1998 are presented in Table 6-4. Precision estimates in ARPD for all meteorological parameters (except for temperature and delta temperature) and O_3 ranged from 0.19 for flow to 81.61 for wetness. All measurements, except precipitation, meet precision criteria. Acceptance criteria for wetness sensors are undefined because the sensors are difficult to align with high precision within one hour of one another. Temperature and delta temperature results are presented as the quarterly average absolute differences (as shown in Table 6-4) because percent differences for these two parameters are not representative of sensor precision. Precision results as ARPD for precipitation often exceeded acceptance criteria as differences in very small volumes of hourly rainfall yield large ARPDs.

Laboratory Analysis of Field Samples

Precision results by site via collocated sampling for filter pack data for 1998 are presented in Table 6-5. Precision estimates in ARPD for all analytes for the two collocated sites ranged from 1.35 for SO_4^{2-} to 21.22 for HNO_3. The greater exceedances from acceptance criteria were for NO_3^- for MCK131, and all analytes except SO_4^{2-} for ASH135. Concentrations for all analytes for ASH135 are extremely low in comparison to other eastern sites, and the NO_3^- concentrations for MCK131 are very low as well.

Precision results by site via collocated sampling at ALH157 for wet deposition data for 1998 are presented in Table 6-6. Precision estimates in ARPD for all analytes ranged from 4.12 for precipitation to 49.56 for Ca^{2+}. The high values for the cations (except H^+) were the result of differences between extremely low concentrations. With a few exceptions, all ARPDs above 20.0 are from concentrations less than 1.0 mg/L.

Analytical Precision

Precision results for filter pack data obtained from analysis of blind and in-run replicates are presented in Table 6-7. The percent differences for in-run replicates ranged from 0.56 for Teflon®-SO_4^{2-} to 8.42 for nylon-SO_4^{2-}. The percent differences for blind replicates ranged from 1.21 for Teflon®-SO_4^{2-} to 12.97 for nylon-SO_4^{2-}. In all but one case, in-run replicates exhibited greater precision than blind replicate results. This result was not unexpected since the blind replicates were analyzed up to 2 or 3 months after analysis of the original sample. At this point, the sample holding times exceeded recommended check limits. It is suspected that this might have been a factor in the decrease in precision in blind replicate analysis in comparison to in-run replicate analysis. In addition, the IC columns could be in slightly different conditions depending on the age of the columns with respect to the original analysis. Because of these reasons, analysis of blind replicates was discontinued as stated previously.

Results of precision estimates for wet deposition sampling by replicate analysis are presented in Table 6-8. The percent differences ranged from 0.07 for NO_2 to 28.9 for H^+. All wet deposition precision results, except for H^+ and Cl^-, were within acceptance criteria.

Network Accuracy

Field Data

Results of accuracy as determined by instrument response relative to independent transfer standards are presented in Table 6-9. The data in Table 6-9 represent all calibrations for all sites in 1998. The table summarizes by quarter the number of instances for each parameter that data acceptance criteria (Table 6-1) were not met. For each exceedance, all pertinent information was reviewed; and data were either adjusted according to the calibration results or invalidated. Data were invalidated only if adjustment was impossible due to the nature of the failure. After second quarter 1998, quarterly calibrations were discontinued and replaced with semi-annual calibrations. This procedural change is reflected in the presentation of results in Table 6-9.

Laboratory Data

Accuracy estimates for filter pack samples for 1998 are presented in Table 6-7. These values ranged from 98.5% for nylon-SO_4^{2-} to 102.6 for nylon-NO_3^-. Accuracy results were within acceptance criteria for all quarters and annually for all analytes.

Table 6-8 also presents the accuracy results for wet deposition sampling. Percent recoveries ranged from 95.1 for Ca^{2+} to 105.2 for Na^+. All accuracy results were within acceptance criteria.

Analysis of Filter Blanks

In August 1998, ESE changed the manufacturer of Teflon® filters (see Table 1-4). This decision was made because of recurring problems with high background levels of NO_3^- on the filters. This problem was first experienced in October 1997. CAPMoN has also been experiencing high background levels on their Teflon® filters. Because of these problems, ESE decided to review the historical record of measured concentrations (i.e., background) on various blank filters for any trends or biases in background levels. This section summarizes the analysis of filter blanks.

Currently, ESE uses three types of filter blanks. Five percent of new Teflon® and nylon and two percent of Whatman impregnated filters are tested for background. If tested filters exceed detection limits, then that box of filters is rejected for use and stored. Prior to late 1997, 2% of filters were tested. Two laboratory blanks are tested per week, and trip (field) blanks are sent quarterly to each monitoring site. The trip blanks are not exposed to the ambient air. Until 1996, trip blanks were shipped monthly to each site.

Table 6-10 summarizes the historical record of filter blanks. The average concentrations from the trip and laboratory blanks are almost equivalent to the detection limits. The data from the acceptance tests illustrate the problem with the NO_3^- background concentrations (e.g., a maximum concentration of 32.18 µg (as N)) on the Teflon® filters. However, boxes of filters with background above the detection limits are not used for field sampling.

Because of the recent problem of high NO_3^- background on Teflon® filters, the field and laboratory blanks were analyzed in more detail. Figure 6-1 shows the background NO_3^- concentrations on Teflon® trip blanks for the period 1990 through 1998. Figure 6-2 shows laboratory blank results. These data show no change in average background concentrations over the 9-year period. A level of quantification (LOQ) can be defined as the average concentration plus three times its standard deviation. The trip blank results shown in Figure 6-1 have been used to calculate an LOQ for each of the 9 years. CASTNet particulate NO_3^- measurements for the period 1992 through 1998 were compared to the calculated LOQ. Appendix B provides the number of weeks by site and year when NO_3^- concentration was less than the LOQ and the number of weeks exceeded 20. This analysis gives an indication of uncertainty in nitrate measurements at those sites with low concentrations (i.e., below LOQ). Typically, four to six sites per year have 20 weeks or more with concentrations less than the LOQ. In general, however, this analysis shows there is not a significant problem with background contamination of CASTNet filters, and there is no trend or biases in background levels, except for the sites with very low NO_3^- concentrations.

CASTNet Visibility Program

Accuracy

The quarterly and annual accuracy results for the SO_4^{2-} and NO_3^- laboratory analyses are detemined by analyzing a NIST reference sample at the beginning and end of each analytical batch to verify the accuracy and stability of the calibration curve (within 5% of the known value). The QC data are summarized in Table 6-7 along with the QC data for the CASTNet base program.

The quarterly and annual accuracy results for select analytes from Teflo® filter packs are determined by analyzing a NIST reference sample at the beginning and end of each batch to verify the accuracy

Table 6-1. Data Quality Objectives for CASTNet Field Measurements

Measurement Parameter	Method	Objectives[1] Precision	Accuracy
Wind Speed	Anemometer	± 0.5 m/sec or ± 10%	± 0.2 m/s < 5.0 m/s ± 5% ≥ 5.0 m/s
Wind Direction	Wind Vane	± 5° or ≃ 2% of full scale	± 5°
Sigma Theta	Wind Vane	± 10%	Undefined
Relative Humidity	Hygrometer	± 10% (of full scale)	± 10% (of full scale)
Solar Radiation	Pyranometer	± 10% (of reading taken at local noon)	± 10%
Precipitation	Tipping Bucket Rain Gauge	± 10% (of reading)	± 0.05 inch[2]
Ambient Temperature	Platinum RTD	± 0.5°C	± 0.25°C
Delta Temperature	Platinum RTD	± 0.25°C	± 0.20°C
O_3	UV Absorbance	± 10% (of reading)	± 10% of acutal value 0.900 < slope < 1.100 -10.0 ppb < int < 10.0 ppb
Filter Pack Flow	Mass Flow Controller	± 10%	±10%
Surface Wetness	Conductivity Bridge	Undefined	Undefined

Note:

m/sec = meters per second.
RTD = resistance-temperature device.

[1]Precision criteria apply to collocated instruments, and accuracy criteria apply to the calibration of instruments.
[2]For target value of 0.50 inch.

and stability of the calibration curve (within 10 to 15% of the known value depending on the analyte). The QC data are summarized in Table 6-11.

Table 6-12 illustrates annual accuracy data for the carbon analysis. The accuracy is determined by the percent recovery of measured total carbon versus expected carbon within 10% of the expected value.

Precision

Aerosol Data

The quarterly and annual precision results for the aerosol samples (nylon, Teflo®, quartz) are presented in Table 6-13. The analytical precision objectives for SO_4^{2-}, NO_3^-, organic and elemental carbon, and fine mass are ±10%. The analytical precision objectives for the trace/crustal elements are ±20%. The precision data are the analytical results from the collocated aerosol samples taken at SIK570/270.

During the third quarter, the Teflo® filters at SIK270 were run without a "mask." Consequently, the XRF measurements are not comparable. The mask was used during the fourth quarter. Results from the collocated denuder/nylon sampling systems do not compare for the fourth quarter. Consequently, precision is poor. ESE investigated the problem and concluded its cause involved gaskets and dirt on the cyclones, which were used randomly by the site operator for the SIK570 and SIK270 nylon filters. New cyclones were provided for the Sikes sampling systems.

Nephelometer Data

Precision is estimated by calculating the relative uncertainty of the data based on operator-initiated zero/span calibration checks. The CASTNet

Table 6-2. Data Quality Objectives for CASTNet Laboratory Measurements*

Analyte	Medium	Method	Acceptance Criteria Precision (ARPD)	Accuracy (%)
pH (as H^+)**	W	Electrometric	12	85 - 115
Conductivity	W	Electrometric	10	85 - 115
Acidity	W	Titrimetric	15	NA
Ammonium (NH_4^+)	W/F	Automated colorimetry	10	90 - 110
Sodium (Na^+)	W/F	ICAP-AE	10	90 - 110
Potassium (K^+)	W/F	ICAP-AE	10	90 - 110
Magnesium (Mg^{2+})	W/F	ICAP-AE	10	90 - 110
Calcium (Ca^{2+})	W/F	ICAP-AE	10	90 - 110
Chloride (Cl^-)	W	Ion chromatography	5	95 - 105
Nitrite (NO_2^-)	W	Ion chromatography	5	NA
Nitrate (NO_3^-)	W/F	Ion chromatography	5	95 - 105
Sulfate (SO_4^{2-})	W/F	Ion chromatography	5	95 - 105
Elemental Carbon	QF	TOA	10	90 - 100
Organic Carbon	QF	TOA	10	90 - 100
Mass	TF	Gravimetric	± 10 µg	± 3 µg
Trace/Crustal Elements	TF	XRF	20	96.8 - 114

Note:
F = filter pack samples.
ICAP-AE = inductively coupled argon plasma-atomic emission.
ARPD = absolute relative percent difference.
W = wet deposition samples.
QF = quartz filter
TF = Teflon® filter

* The precision criteria apply to the laboratory analysis of field samples and laboratory replicates.

** Precision and accuracy results are based on H^+ concentrations. The accuracy and precision criteria represent approximately ±0.05 pH unit.

nephelometer precision objectives are ±15%. The nephelometer precision results for 1998 are presented in Table 6-14.

Data Completeness

Tables 6-15 through 6-18 present data completeness statistics for continuous, filter(dry deposition), precipitation chemistry, and visibility measurements for 1998. The meteorological, O_3, precipitation, and visibility chemistry data are based on those sites operated by ESE. The dry deposition concentration statistics are based on all CASTNet sites. ESE was responsible for operation of EPA-sponsored sites and chemical analysis of all exposed filters. ARS was responsible for field operations of NPS-sponsored sites. Average data capture exceeded 90% for the four data sets. However, the data completeness statistics for the continuous measurements are somewhat lower than for previous years. Nineteen ninety-eight was the first year ESE performed semi-annual calibrations, rather than quarterly calibrations. Data completeness for filter sampling was excellent. Only one site (Sequoia National Park - SEK402) missed the 90% goal. Data completeness for precipitation samples was also excellent. Concentration measurements from the nylon filters at Sikes were problematical during the last few months of 1998. Otherwise, completeness statistics for the visibility aerosol measurements are above 95%.

Table 6-3. Calibration Acceptance Criteria for CASTNet Field Measurements

Measurement Parameter	Measurement Method	Calibration Method	Acceptance Criteria
Wind Speed	Anemometer	Adjustable Synchronous Motor	±0.2 m/sec < 5 m/sec ±5% ≥ 5 m/sec
Wind Direction	Wind Vane	Vane aligned with compass sighted target	±3° each point
Relative Humidity (RH)	Thin Film Capacitor	Transfer Sensor or standard salts	±10% RH <80% ±5% RH ≥80%
Solar Radiation	Pyranometer	Transfer Sensor	±5% of average
Precipitation	Tipping Bucket Gauge	Know Volume Addition	±0.02 inches at 0.50 inches
Temperature	Platinum RTD	Certified Platinum RTD in isothermal bath	±0.15°C
Delta Temperature	Platinum RTD	Certified Platinum RTD in isothermal bath	±0.15°C
O_3	UV Photometric Analyzer	Certified Transfer Photometer	±5% of actual for any value 0.9500 < slope < 1.050 -3.0 ppb < Intercept < 3.0 ppb r^2 > 0.995
Surface Wetness	Conductivity Bridge	Test with 230-240 KW resistance	Full-scale response to test resistance
Filter Pack Flow	Mass Flow Controller	Mass Flow Meter or Dry Piston Meter	±2% of actual flow rate

Table 6-4. Precision (Mean ARPD) for Continuous Data via Collocated Sampling for 1998

Site ID Quarter	Temp*	Delta Temp*	Relative Humidity	Solar Radiation	Ozone	Wind Speed	Wind Direction	Sigma Theta	Prec.	Wetness	Flow
ASH135/235											
First	0.19	0.23	3.54	4.39	0.65	1.24	0.70	3.66	20.30	81.61	0.19
Second	0.14	0.21	2.28	1.63	1.31	2.73	0.92	3.01	33.20	21.88	0.21
Third	0.05	0.07	2.91	1.40	2.11	2.06	0.99	2.90	21.41	12.95	0.19
Fourth	0.08	0.03	3.76	3.18	2.19	2.08	1.09	2.90	36.36	13.73	0.24
Annual	0.12	0.14	3.12	2.65	1.57	2.03	0.93	3.12	27.82	32.54	0.21
MCK131/231											
First	0.06	0.12	3.72	5.63	1.94	2.47	1.17	1.91	15.91	14.53	0.20
Second	0.22	0.09	5.69	3.02	1.54	3.64	0.93	2.53	7.73	25.33	0.56
Third	0.11	0.11	7.38	2.75	1.72	3.85	2.24	3.55	6.69	18.24	0.53
Fourth	0.21	0.15	2.90	2.60	6.71	5.47	1.62	3.23	13.48	14.84	0.46
Annual	0.15	0.12	4.92	3.50	2.98	3.86	1.49	2.81	10.95	18.24	0.44

Note: ARPD = Absolute Relative Percent Difference.
Prec. = Precipitation.
* Absolute Relative Difference Reported.

Table 6-5. Precision (Mean ARPD) for Filter Pack Data via Collocated Sampling for 1998

Site ID	Quarter	SO_4^{2-}	NO_3^-	HNO_3	SO_2	NH_4^+	Total NO_3^-
ASH135/235	First	3.91	12.54	10.82	5.14	8.73	9.75
	Second	4.95	15.86	9.03	17.50	13.32	9.28
	Third	3.22	16.53	17.33	11.33	8.11	13.35
	Fourth	8.22	9.82	21.22	8.87	8.31	14.90
	Annual	5.10	13.71	14.68	10.69	9.64	11.86
MCK131/231	First	1.35	6.54	3.73	2.89	1.60	2.89
	Second	3.72	13.94	3.11	3.41	3.25	3.18
	Third	5.00	14.06	6.52	4.65	6.34	5.47
	Fourth	7.81	15.54	8.29	9.29	7.71	8.08
	Annual	4.53	12.64	5.45	5.02	4.79	4.95

Note: ARPD = Absolute Relative Percent Difference.

Table 6-6. Precision (Mean ARPD) for Wet Deposition Data via Collocated Sampling for 1998

Site ID	Quarter	H^+	NH_4^+	Na^+	Ca^{2+}	Mg^{2+}	SO_4^{2-}	NO_3^-	Prec.
ALH157/257	First	19.55	20.45	28.44	36.30	37.18	16.64	25.89	4.12
	Second	20.22	26.32	28.33	20.41	29.18	15.95	14.33	7.16
	Third	7.66	26.46	15.98	19.35	18.53	11.37	11.14	5.21
	Fourth	18.03	33.88	30.55	49.56	44.88	25.36	26.19	13.90
	Annual	16.23	26.25	25.58	30.87	32.00	16.93	19.33	7.31

Note: ARPD = Absolute Relative Percent Difference.
Prec. = Precipitation amount from Belfort rain gauge.

Table 6-7. Laboratory Accuracy (Percent Recovery) and Precision (Mean Absolute Percent Difference) for Filter Pack Data (µg/filter) for 1998

	Teflon®		Nylon		Whatman	
	SO_4^{2-}	NO_3^-	SO_4^{2-}	NO_3^-	SO_4^{2-}	NO_3^-
First Quarter						
Accuracy	100.5	100.3	100.8	101.7	98.7	99.8
Precision Blind Replicate	1.69	2.41	12.97	2.70	3.35	4.48
Precision In-Run Replicate	0.56	0.84	5.77	1.78	2.16	4.66
Second Quarter						
Accuracy	100.7	100.4	101.3	100.2	98.7	99.9
Precision Blind Replicate	1.21	2.43	9.25	4.12	5.73	7.36
Precision In-Run Replicate	0.59	1.19	6.06	1.91	2.92	5.55
Third Quarter						
Accuracy	100.1	100.1	98.5	102.6	100.0	100.3
Precision Blind Replicate	1.35	5.94	11.64	2.36	6.01	9.15
Precision In-Run Replicate	0.76	3.06	4.63	1.79	3.15	7.15
Fourth Quarter						
Accuracy	99.4	102.1	99.6	102.2	101.8	102.3
Precision Blind Replicate	NA	NA	NA	NA	NA	NA
Precision In-Run Replicate	2.58	3.68	8.42	3.53	2.41	3.03
Annual						
Accuracy	100.1	100.7	100.0	101.8	99.8	100.7
Precision Blind Replicate	1.42	3.49	12.03	3.95	5.05	7.00
Precision In-Run Replicate	1.14	2.09	6.30	2.81	2.54	4.91

Note: NA = not applicable (discontinued).

Table 6-8. Laboratory Accuracy (Percent Recovery) and Precision (Mean Absolute Percent Difference) for Wet Deposition Data for 1998

	H^+	Conductivity	SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Ca^{2+}	Mg^{2+}	Na^+	K^+	NO_2	Acidity
First Quarter												
Accuracy	99.7	98.2	100.2	101.5	100.5	100.6	95.1	98.6	103.1	102.2	NA	NA
Precision	2.39	1.85	0.56	0.75	3.48	3.38	2.81	0.41	0.48	1.17	0.89	1.32
Second Quarter												
Accuracy	99.6	96.4	100.2	101.2	100.7	100.7	101.8	97.9	105.2	100.0	NA	NA
Precision	7.18	0.87	0.49	0.56	5.86	3.13	3.33	1.41	0.88	1.79	3.26	4.73
Third Quarter												
Accuracy	100.4	97.1	100.7	101.7	101.7	98.02	104.1	101.1	99.3	96.2	NA	NA
Precision	12.09	0.93	0.74	0.82	12.37	3.91	3.65	1.58	0.67	0.39	0.96	3.83
Fourth Quarter												
Accuracy	100.6	96.4	100.9	102.3	100.0	100.1	105.0	101.7	101.0	99.9	NA	NA
Precision	28.9	3.91	2.07	0.54	5.14	7.34	4.65	2.45	1.15	2.42	0.07	7.05
Annual												
Accuracy	100.0	96.7	100.5	101.7	100.6	99.9	100.9	99.6	102.4	99.9	NA	NA
Precision	12.97	1.96	0.89	0.61	6.59	4.50	3.56	1.46	0.79	1.25	1.03	4.18

Note: NA = Reference sample not available.

Table 6-9. Accuracy Results* for Continuous Measurements Determined from Results of Quarterly and Semi-annual Calibrations

Quarter (Number of Sites)	Temperature		Delta Temperature		Wind Speed		Wind Dir.	Rel. Hum.	Solar Rad.	Prec.	Wetness	O_3	Flow
	Ambient	0-5°C	Ambient	0-5°C	Low	High							
First (n = 50)	11	8	3	3	5	1	5	1	1	2	0	2	1
Second (n = 50)	9	5	5	4	1	0	4	1	2	2	0	0	3
Third & Fourth (n = 50)	12	6	2	2	2	4	4	2	5	1	0	2	0

Note: Prec. = precipitation.
Rel. Hum. = relative humidity.
Solar Rad. = solar radiation.
Wind Dir. = wind direction.

* Number of times an instrument did not meet accuracy criteria (Table 6-1).

Table 6-10. Summary of Filter Blanks

Trip Blanks (1990 - 1998)					
Parameter Name	**Detection Limit**	**Total No.**	**Avg T.ug**	**Std. Dev.**	**Max**
Teflon®-NH_4^+-N	0.50 T.µg	3963	0.52	0.19	10.52
Teflon®-NO_3^--N	0.20 T.µg	3974	0.21	0.05	0.88
Teflon®-SO_4^{2-}	1.00 T.µg	3969	1.00	0.11	6.45
Nylon-NO_3^--N	0.20 T.µg	3944	0.21	0.16	9.50
Nylon-SO_4^{2-}	1.00 T.µg	3956	1.02	0.29	15.17
Whatman-NO_3^--N	0.40 T.µg	3941	0.58	0.29	3.10
Whatman-SO_4^{2-}	2.00 T.µg	3925	2.65	1.60	22.61

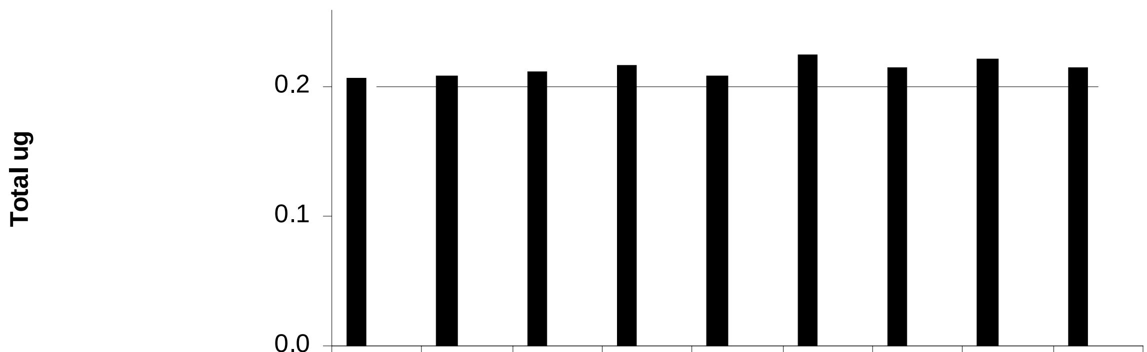
Laboratory Blanks (1990 - 1998)					
Parameter Name	**Detection Limit**	**Total No.**	**Avg T.ug**	**Std. Dev.**	**Max**
Teflon®-SO_4^{2-}	1.00 T.µg	772	1.01	0.20	6.58
Teflon®-NH_4^+-N	0.50 T.µg	770	0.53	0.15	2.33
Teflon®-NO_3^--N	0.20 T.µg	767	0.21	0.06	1.51
Nylon-SO_4^{2-}	1.00 T.µg	762	1.01	0.15	4.96
Nylon-NO_3^--N	0.20 T.µg	769	0.20	0.00	0.23
Whatman-SO_4^{2-}	2.00 T.µg	768	2.19	0.73	8.38
Whatman-NO_3^--N	0.40 T.µg	771	0.46	0.18	2.66

Acceptance Test Values (1990 - 1998)						
Parameter Name	**Detection Limit**	**Total No.**	**No. Above DL**	**Avg T.ug**	**Std. Dev.**	**Max**
Teflon®-NO_3^-, -N	0.20 T.µg	1760	182	0.64	2.49	32.18
Teflon®-SO_4^{2-}	1.00 T.µg	1760	5	2.82	2.00	5.01
Nylon-NO_3^-, -N	0.20 T.µg	1609	96	0.33	0.13	0.63
Nylon-SO_4^{2-}	1.00 T.µg	1609	63	2.23	1.76	6.24
Whatman*-SO_4^{2-}	2.00 T.µg	3372	232	3.22	1.25	9.71

Note: T = Total

Whatman filters are not analyzed for ambient NO_3^-. The blank results are used only for QC.

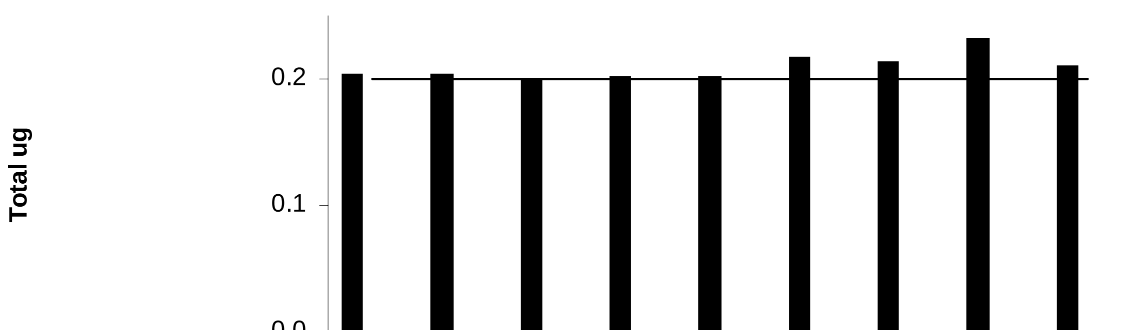
Figure 6-1. Results of Analysis for NO_3^- on Trip Blanks



	1990	1991	1992	1993	1994	1995	1996	1997	1998
Avg Conc	0.21	0.21	0.21	0.22	0.21	0.22	0.21	0.22	0.22
> Detection Limit	66	24	108	160	52	99	25	45	30
Max Conc	0.46	0.36	0.60	0.81	0.78	0.88	0.84	0.74	0.78
Std. Dev.	0.03	0.03	0.04	0.06	0.05	0.07	0.06	0.07	0.06
Detection Limit	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Count	659	136	700	777	563	490	194	267	188

Collection Year

Figure 6-2. Results of Analysis for NO_3^- on Laboratory Blanks



	1990	1991	1992	1993	1994	1995	1996	1997	1998
Avg Conc	0.203	0.204	0.200	0.202	0.202	0.216	0.214	0.231	0.209
> Detection Limit	3	6	3	5	6	14	9	15	12
Max Conc	0.322	0.351	0.219	0.299	0.258	0.604	0.453	1.507	0.340
Std. Dev.	0.017	0.020	0.003	0.012	0.009	0.055	0.049	0.149	0.029
Detection Limit	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Count	63	74	91	84	95	93	91	100	82

Collection Year

Table 6-11. Quarterly and Annual Accuracy Results for Select Analytes from Teflo® Filters for 1998 (Chester LabNet)

Analyte/SRM	Silicon/1832	Silicon/1833	Calcium/1832	Titanium/1833	Iron/1833
1st Quarter	98.00	97.10	103.05	100.25	101.40
2nd Quarter	99.2	98.8	104.3	100.9	98.5
3rd Quarter	100.7	101.2	104.2	98.7	99.9
4th Quarter	100.8	100.0	103.6	97.1	105.1
Annual Average	99.68	99.28	103.79	99.24	101.23

Note: SRM is standard reference method for analytical chemistry measurements.

Table 6-12. Quarterly and Annual Accuracy Results from Quartz Filters for 1998 (Sunset Laboratory)

Date	Total Carbon (µg/sq cm)	Expected Total Carbon	Percent Recovery
First Quarter	69.25	68.56	101.01
Second Quarter	64.53	62.43	103.37
Third Quarter	63.82	63.77	100.08
Fourth Quarter	102.22	102.59	99.64
Annual Average	–	–	101.03

Note: The quarterly results are based on approximately 20 samples with expected carbon values that range from 20 to 200 µg/sq cm.

Table 6-13. Quarterly and Annual Precision Results (Mean ARPD) for Select Analytes from Collocated Aerosol Samples for 1998

Analyte	NO_3^-	SO_4^{2-}	Elemental Carbon	Organic Carbon	Calcium	Iron	Fine Mass	Sulfur	Silicon
1st Quarter	8.57	5.49	23.84[1]	5.24	15.09	10.86	9.69	11.85	10.92[2]
2nd Quarter	18.28[1]	9.67	12.22[1]	7.00	9.83	6.76	5.49	2.73	11.50
3rd Quarter	9.52	2.35	20.00[1]	8.43	23.94	21.83	3.21	32.19	22.38
4th Quarter	55.26	70.57	24.56[1]	7.65	10.22	6.79	6.36	7.12	10.98
Annual Average	N/A	N/A	20.16	7.08	14.77	11.56	6.19	13.47	13.95

[1] The elevated percent difference is a result of low mean concentrations.

[2] The reported percent difference does not include one outlier of 86.46 percent from the February 4, 1998 sample date.

Note: Results are derived from data collected at SIK570 and SIK270. During the third quarter, the Teflo® filters at SIK270 were run without a "mask." Consequently, the XRF measurements are not comparable. The mask was used during the fourth quarter. Results from the collocated denuder/nylon sampling systems do not compare for the fourth quarter. Consequently, precision is poor. ESE investigated the problem and concluded its cause involved gaskets and dirt on the cyclones, which were used randomly for the SIK570 and SIK270 nylon filters. New cyclones were provided for the Sikes sampling systems.

Table 6-14. Quarterly and Annual Precision Results for Nephelometer Data for 1998

Sampling Period	CDZ571	QAK572
First Quarter	10.5%	8.9%
Second Quarter	6.0%	15.4%
Third Quarter	11.7%	25.4%
Fourth Quarter	9.3%	8.8%
Annual Average	9.4%	14.6%

Table 6-15. Percent Data Completeness for Continuous Measurements for 1998

Site ID	Temperature	Delta Temperature	Relative Humidity	Solar Radiation	Ozone	Precipitation	Wind Speed	Wind Direction	Sigma Theta	Flow Rate	Scalar Wind Speed	Wetness	Average
ABT147	99.4	99.4	98.9	99.5	98.4	99.4	98.5	98.5	98.5	99.8	98.5	99.4	99.0
ALH157	77.5	74.8	99.2	99.6	98.7	98.7	91.2	91.2	91.2	99.8	90.6	96.7	92.4
ANA115	99.0	98.9	98.9	97.7	94.3	98.6	98.8	98.8	98.6	99.5	97.9	97.8	98.2
ARE128	95.4	95.4	99.5	99.4	98.6	98.0	99.2	99.2	99.2	98.6	99.2	99.4	98.4
ASH135	97.9	97.9	99.2	99.4	98.0	98.9	96.2	96.2	96.2	99.9	96.0	93.0	97.4
ASH235	99.2	99.2	99.4	99.6	98.1	99.1	97.0	97.0	97.0	99.8	97.0	98.7	98.4
BEL116	93.7	93.6	69.6	93.7	92.9	93.5	93.3	93.3	93.3	96.7	93.2	72.9	90.0
BFT142	94.7	93.9	92.4	88.8	97.8	97.2	97.1	97.1	97.1	99.2	97.1	97.1	95.8
BVL130	98.5	98.5	98.5	98.6	98.6	98.6	97.9	97.9	97.4	99.1	97.6	98.0	98.3
BWR139	98.7	87.1	98.7	98.9	97.7	98.7	98.6	98.6	98.6	99.8	98.6	88.3	96.9
CAD150	97.8	85.4	97.8	97.8	97.2	96.3	97.4	97.4	97.3	98.1	96.8	97.1	96.4
CAT175	97.1	97.1	97.1	97.8	34.9	97.0	96.7	96.7	96.7	99.4	96.6	96.7	92.0
CDR119	98.7	91.9	98.7	98.9	93.6	99.3	97.9	97.9	97.9	99.1	97.9	99.2	97.6
CDZ571	97.0	96.9	82.8	93.6	96.0	95.1	35.9	35.9	35.9	NA	97.0	86.2	77.5
CKT136	98.9	94.9	92.2	99.4	98.0	99.0	70.4	70.3	70.3	99.7	98.8	98.9	90.9
CND125	98.8	98.8	89.8	85.9	95.8	95.3	97.2	97.2	97.2	99.8	97.2	93.0	95.5
CNT169	98.4	97.8	98.5	98.7	97.0	97.8	92.1	92.1	92.1	99.1	92.1	95.5	95.9
COW137	98.8	98.8	99.0	99.2	91.4	98.5	98.8	98.8	98.8	97.9	98.8	97.1	98.0
CTH110	98.7	98.7	98.1	99.1	98.2	99.5	94.9	94.9	94.9	99.2	97.4	96.8	97.5
CVL151	94.9	90.5	95.7	95.9	95.0	94.4	88.0	88.0	88.0	99.3	94.2	95.0	93.2
DCP114	99.4	99.4	96.8	96.6	98.4	99.1	96.5	96.5	96.5	99.6	99.4	98.6	98.1
EGB181	98.8	98.8	99.2	93.2	NA	98.5	99.1	99.1	99.1	99.0	99.0	98.4	98.4
ESP127	98.3	97.0	97.1	97.3	96.0	97.1	97.1	97.1	97.1	99.6	96.8	86.7	96.4
GAS153	93.9	93.9	78.0	83.9	94.9	95.5	95.7	95.7	95.6	99.6	95.9	95.6	93.2
GTH161	93.2	93.2	85.8	97.6	98.2	98.5	99.1	99.1	99.1	99.6	98.8	99.2	96.8
HOW132	81.7	56.9	77.1	89.2	96.5	98.6	76.2	76.2	76.2	99.1	79.4	87.2	82.9
KEF112	98.2	96.3	98.3	98.5	91.1	97.6	97.6	97.6	97.6	98.2	97.6	97.1	97.1
LRL117	98.4	92.1	72.7	91.1	97.7	98.9	95.3	95.3	95.3	99.9	98.9	74.6	92.5
LYE145	99.0	99.1	76.4	85.3	21.2	98.4	88.7	88.7	88.7	97.6	94.7	98.9	86.4
LYK123	95.7	72.9	99.6	96.5	98.7	99.6	99.6	99.6	99.6	99.5	99.6	95.0	96.3
MCK131	96.9	75.8	94.3	97.6	96.4	97.8	95.3	95.3	95.3	99.2	95.3	91.9	94.3
MCK231	95.8	94.3	96.8	97.5	83.3	96.1	96.7	96.7	95.5	98.7	96.7	96.7	95.4
MKG113	99.0	99.0	99.0	99.2	95.3	98.7	98.4	98.4	98.4	99.2	98.7	97.1	98.4
OXF122	99.4	99.4	99.4	99.6	97.5	99.2	99.0	99.0	99.0	99.6	99.0	97.4	99.0
PAR107	99.4	99.4	99.4	96.9	96.9	85.1	99.2	99.2	99.2	99.9	99.0	91.8	97.1
PED108	98.7	98.6	98.7	98.9	90.2	92.4	92.0	92.0	92.0	99.1	98.1	82.8	94.5
PND165	96.2	91.9	99.6	99.7	98.7	99.6	99.4	99.4	99.4	96.5	99.4	97.3	98.1
PNF126	94.6	87.7	92.1	88.2	93.6	90.4	61.8	61.8	61.8	99.1	61.8	78.3	80.9
PRK134	99.2	98.8	97.6	99.4	97.9	98.4	78.7	78.7	78.7	97.0	78.2	95.6	91.5
PSU106	98.8	92.5	82.9	99.2	52.4	98.9	98.3	98.3	98.3	99.8	98.9	99.0	93.1
QAK572	97.1	90.7	97.1	97.2	94.9	97.0	97.1	97.1	97.1	NA	97.1	95.8	96.2
SAL133	98.3	98.3	98.3	91.2	96.8	99.4	94.4	94.4	94.5	99.7	97.8	91.9	96.3
SND152	95.6	95.6	80.8	99.7	98.6	97.8	99.3	99.3	99.3	99.8	99.3	98.9	97.0
SPD111	99.0	95.1	99.0	98.9	97.6	97.9	97.7	97.7	97.7	99.3	98.6	98.2	98.1
STK138	92.9	0.0	97.6	97.8	92.1	94.5	93.2	93.2	93.2	98.9	97.5	84.3	86.3
SUM156	82.8	67.0	61.3	85.7	86.1	84.5	97.8	97.6	97.6	86.2	92.4	85.0	85.3
UVL124	99.2	96.1	97.6	99.3	98.6	99.2	99.2	99.2	99.2	99.8	99.2	98.6	98.8
VIN140	98.2	97.8	98.1	98.3	97.3	93.4	97.5	97.5	97.5	99.6	96.9	97.0	97.4
VPI120	91.0	91.0	98.7	99.0	95.3	96.6	98.7	98.7	98.7	99.6	96.4	96.4	96.7
WEL149	97.8	97.5	97.6	73.4	96.8	97.5	97.7	97.7	97.4	58.1	97.3	97.3	92.2
WSP144	97.8	97.8	99.1	99.3	98.1	99.2	99.1	99.1	99.1	99.4	99.1	97.0	98.7
WST109	99.4	99.3	99.4	99.7	98.5	99.2	74.6	74.6	74.6	99.0	84.2	99.1	91.8
AVERAGE	96.5	91.4	93.6	95.9	92.5	97.1	93.2	93.2	93.2	98.1	95.6	94.1	94.5

Table 6-16. Percent Data Completeness for Filter Concentrations for 1998 (page 1 of 2)

Site ID	Teflon SO_4^{2-}	Teflon NO_3^-	Teflon NH_4^+	Nylon HNO_3	Nylon SO_4^{2-}	Whatman NO_3^-	Whatman SO_2
ABT147	96.2	96.2	96.2	98.1	98.1	98.1	98.1
ACA416	92.3	92.3	92.3	92.3	92.3	92.3	92.3
ALH157	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ANA115	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ARE128	94.2	94.2	96.2	96.2	96.2	96.2	96.2
ASH135	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ASH235	100.0	100.0	100.0	100.0	100.0	100.0	100.0
BBE401	98.1	98.1	98.1	98.1	98.1	98.1	98.1
BEL116	92.3	92.3	92.3	92.3	92.3	92.3	92.3
BFT142	100.0	100.0	100.0	100.0	100.0	100.0	100.0
BVL130	98.1	98.1	98.1	98.1	98.1	100.0	100.0
BWR139	98.1	98.1	98.1	96.2	96.2	100.0	100.0
CAD150	94.2	94.2	94.2	94.2	94.2	94.2	94.2
CAN407	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CAT175	100.0	100.0	100.0	98.1	98.1	100.0	100.0
CDR119	96.2	96.2	96.2	96.2	96.2	98.1	98.1
CHA467	96.2	96.2	96.2	96.2	96.2	96.2	96.2
CKT136	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CND125	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CNT169	100.0	100.0	100.0	100.0	100.0	100.0	100.0
COW137	98.1	98.1	98.1	98.1	98.1	96.2	96.2
CTH110	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CVL151	96.2	96.2	96.2	98.1	98.1	98.1	98.1
DCP114	96.2	96.2	96.2	96.2	96.2	98.1	98.1
DEN417	100.0	100.0	100.0	98.1	98.1	100.0	100.0
DEV412	96.2	96.2	96.2	96.2	96.2	96.2	96.2
EGB181	98.1	98.1	98.1	98.1	98.1	98.1	98.1
ESP127	100.0	100.0	100.0	100.0	100.0	100.0	100.0
EVE419	100.0	100.0	100.0	100.0	100.0	100.0	100.0
GAS153	98.1	98.1	98.1	98.1	98.1	98.1	98.1
GLR468	94.2	94.2	94.2	94.2	94.2	94.2	94.2
GRB411	100.0	100.0	100.0	100.0	100.0	100.0	100.0
GRC474	98.1	98.1	98.1	98.1	98.1	98.1	98.1
GRS420	98.1	98.1	98.1	98.1	98.1	98.1	98.1
GTH161	100.0	100.0	100.0	100.0	100.0	100.0	100.0
HOW132	100.0	100.0	100.0	100.0	100.0	100.0	100.0
JOT403	94.2	94.2	94.2	96.2	96.2	96.2	96.2
KEF112	96.2	96.2	96.2	96.2	96.2	96.2	96.2
LAV410	100.0	100.0	100.0	100.0	100.0	100.0	100.0
LRL117	100.0	100.0	100.0	100.0	100.0	100.0	100.0
LYE145	94.2	94.2	94.2	94.2	94.2	96.2	96.2
LYK123	100.0	100.0	100.0	100.0	100.0	100.0	100.0
MCK131	98.1	98.1	98.1	98.1	98.1	96.2	96.2
MCK231	98.1	98.1	98.1	98.1	98.1	98.1	98.1
MEV405	98.1	98.1	98.1	98.1	98.1	98.1	98.1
MKG113	98.1	98.1	98.1	98.1	98.1	100.0	100.0
MOR409	92.3	92.3	92.3	90.4	90.4	96.2	96.2

Table 6-16. Percent Data Completeness for Filter Concentrations for 1998 (page 2 of 2)

Site ID	Teflon SO_4^{2-}	Teflon NO_3^-	Teflon NH_4^+	Nylon HNO_3	Nylon SO_4^{2-}	Whatman NO_3^-	Whatman SO_2
NCS415	96.2	96.2	96.2	96.2	96.2	98.1	98.1
OLY421	98.1	98.1	98.1	98.1	98.1	100.0	100.0
OXF122	98.1	98.1	98.1	98.1	98.1	98.1	98.1
PAR107	98.1	98.1	98.1	98.1	98.1	100.0	100.0
PED108	98.1	98.1	98.1	98.1	98.1	98.1	98.1
PIN414	90.4	90.4	90.4	90.4	90.4	90.4	90.4
PND165	94.2	94.2	94.2	94.2	94.2	94.2	94.2
PNF126	98.1	98.1	98.1	98.1	98.1	98.1	98.1
PRK134	98.1	98.1	96.2	98.1	98.1	98.1	98.1
PSU106	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ROM406	98.1	98.1	98.1	98.1	98.1	98.1	98.1
SAL133	96.2	96.2	96.2	96.2	96.2	100.0	100.0
SEK402	71.2	71.2	71.2	71.2	71.2	71.2	71.2
SHN418	96.2	96.2	96.2	96.2	96.2	98.1	98.1
SND152	98.1	98.1	98.1	98.1	98.1	100.0	100.0
SPD111	100.0	100.0	100.0	100.0	100.0	100.0	100.0
STK138	96.2	96.2	96.2	96.2	96.2	98.1	98.1
SUM156	96.2	96.2	96.2	96.2	96.2	96.2	96.2
THR422	100.0	100.0	100.0	100.0	100.0	100.0	100.0
UVL124	98.1	98.1	98.1	98.1	98.1	100.0	100.0
VII423	98.1	98.1	98.1	98.1	98.1	98.1	98.1
VIN140	100.0	100.0	100.0	100.0	100.0	100.0	100.0
VOY413	98.1	98.1	98.1	98.1	98.1	100.0	100.0
VPI120	98.1	98.1	98.1	98.1	98.1	100.0	100.0
WEL149	98.1	98.1	98.1	96.2	96.2	98.1	98.1
WSP144	100.0	100.0	100.0	100.0	100.0	100.0	100.0
WST109	100.0	100.0	100.0	100.0	100.0	100.0	100.0
YEL408	98.1	98.1	98.1	98.1	98.1	98.1	98.1
YOS404	94.2	94.2	94.2	94.2	94.2	94.2	94.2

Table 6-17. Percent Data Completeness for Precipitation Chemistry for 1998

Site ID	pH	Mg	Na	NH_4^+	NO_3^-	SO_4^{2-}
ABT147	100.0	100.0	100.0	100.0	100.0	100.0
ALH157	97.6	97.6	97.6	97.6	97.6	97.6
ALH257	100.0	100.0	100.0	100.0	100.0	100.0
ANA115	97.6	100.0	100.0	100.0	100.0	100.0
ARE128	100.0	100.0	100.0	100.0	100.0	100.0
BFT142	93.0	93.0	93.0	93.0	93.0	93.0
CDR119	93.5	93.5	93.5	93.5	93.5	93.5
CHA467	100.0	100.0	100.0	100.0	100.0	100.0
CND125	100.0	100.0	100.0	100.0	100.0	100.0
DCP114	100.0	100.0	100.0	100.0	100.0	100.0
GTH161	93.6	100.0	100.0	100.0	100.0	100.0
LYE145	86.4	86.4	86.4	86.4	86.4	86.4
LYK123	100.0	100.0	100.0	100.0	100.0	100.0
PED108	100.0	100.0	100.0	100.0	100.0	100.0
PNF126	100.0	100.0	100.0	100.0	100.0	100.0
PRK134	97.1	100.0	100.0	100.0	100.0	100.0
SCR180	100.0	100.0	100.0	100.0	100.0	100.0
SPD111	100.0	100.0	100.0	100.0	100.0	100.0
SUM156	97.1	97.1	97.1	97.1	97.1	97.1
UVL124	100.0	100.0	100.0	100.0	100.0	100.0

Table 6-18. Data Completeness for Aerosol Samples

	Number of Possible Samples	Number of Valid Samples	Percent Completeness
First Quarter 1998			
Nylon	127	120	94.5
Teflo®	127	119	93.7
Quartz	127	119	93.7
Combined*	127	118	92.9
Second Quarter 1998			
Nylon	128	125	97.7
Teflo®	128	125	97.7
Quartz	128	125	97.7
Combined*	128	121	94.6
Third Quarter 1998			
Nylon	127	123	96.9
Teflo®	127	121	95.3
Quartz	127	122	96.1
Combined*	127	121	95.3
Fourth Quarter 1998			
Nylon	137	109†	79.6
Teflo®	137	133	97.1
Quartz	137	133	97.1
Combined*	137	–	–
Cumulative for 1998			
Nylon	519	477	95.0
Teflo®	519	498	96.0
Quartz	519	499	96.2
Combined*	519	–	–

Note:

* All 3 valid filters.
† All nylon filter data for SIK570/SIK270 are considered invalid.